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THE BATHYMETRY OF LAKES KING AND VICTORIA

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Abstract: This report describes a recent bathymetric survey of part of the Gippsland Lakes. Charts giving the results are included.

The point at which rivers debouche is almost always of interest, being frequently the site of commercial, recreational and environmental activity with all the conflicts implied by these concurrent uses. These regions are of special interest to the engineer since the whole nature of the estuary is determined by a number of hydraulic forces in delicate balance so that quite small changes can have dramatic consequences. The estuaries around the southeast coast of Australia, from Lake Alexandrina to Malacoota Inlet and beyond, are unusual, and comprise a lake communicating with the sea across a narrow, variable sand bar. They may be cut-off from the sea by the sand bar for large parts of the year. One of the largest of these, and quite the most complex, is at Lakes Entrance in Victoria. The mouth of this estuary, at Lakes Entrance, is artificially stabilised and maintained open throughout the year. Notwithstanding the commercial and scientific interest of this system, there has been surprisingly little modern systematic measurement of its parameters.

The Department of Mechanical Engineering at Monash University, however, has been studying the lake system both theoretically and observationally. In particular, it has been conducting extended student excursions to the region for more than ten years, and this report gives some initial observations of bathymetry obtained on those trips. There appears to have been no general survey of the depths in the Lakes since the fine work of Mason 1893-95. This covers only Lake King and the western half of Lake Victoria (Mason 1895). More recently, the State Electricity Commission of Victoria has surveyed Lake Wellington (SEC 1972a) and, rather sparsely, the western end of Lake Victoria (SEC 1972b). The Ports and Harbours Division of the Public Works Department, Victoria, is conducting a survey of a large part of the lake system. There are no published recent data for Lake King. To remedy this deficiency we have, during 1979 and 1980, surveyed the whole of Lakes Victoria and King.

SURVEY METHODS

These surveys were made using the Department's 8 m aluminium boat. Depths were measured with a Raytheon DB819 echo-sounder; the resolution and probable accuracy of measurement is 0.1 m. Depth readings from the echo-sounder were first corrected for the depth of immersion of the echo-sounder. They were then converted to AHD by linear interpolation between two or three specially established tide gauges which were connected by short closed levelling traverses to bench marks. Location is a problem throughout the Lakes as the shores are (navigationally) rather featureless. We did not have access to radio-location equipment for these surveys and have had to rely on traditional methods, augmenting the natural landmarks with buoys and, for the Lake King survey where the problems are particularly acute, with balloons tethered at known points. Sightings, which were made using both compass and sextant, were taken at the beginning and end of each traverse, which the boat attempted to cover at uniform velocity, and at one or two intermediate points as a check on the navigation. Intermediate positions were then located by interpolation. Overall, we estimate the maximum error in position to be 20 m nearshore and 50 m far from shore with typical values being less. There is, indeed, greater uncertainty about the location of the shoreline in some parts of our maps than this.

The echo-sounder used a frequency of 208 kHz ensuring a clear reflection from the upper surface of the bed, whether the latter was silt or sand. In a few localities echoes were obtained from weed or even detritus on the bed but in these cases the bed was still readily identifiable. Comparison tests between lead-line and echo-sounding did not show differences as even the silt bed was firmly consolidated.

Processing of Observations

All the depth data obtained have been stored digitally, the coordinates of each sounding being converted automatically from the field plotting sheets on an x-y digitising table. Each data set is held as a separate file, and so can be plotted selectively. The coastline of the entire system, referred to the same coordinates, is also stored digitally. We can thus call up details of any part of the Lakes. Figures 1-3 are copied directly from the computer output.

BATHYMETRY

The SECV measurements in Lake Victoria are included in Figs 1 and 2; the agreement with our survey is good, but the floor is fairly uniform so this is not a very critical test. Our survey of Lake King is shown in Fig. 3, and our points are compared with (every 4th of) Mason's points. The overall impression is that the values have changed very little, which refutes the canard that there has been a secular change of depth in the Lakes in the past 100 years.

However, closer examination shows some systematic variations. While no modern measurements are significantly shallower than Mason's, locally they may be

Fig. 1—Lake Victoria, western half—modern bathymetry. Depths in decimetres. SEC △; Monash ●.

Fig. 2—Lake Victoria, eastern half—modern bathymetry. Depths in decimetres. SEC △; Monash ●.

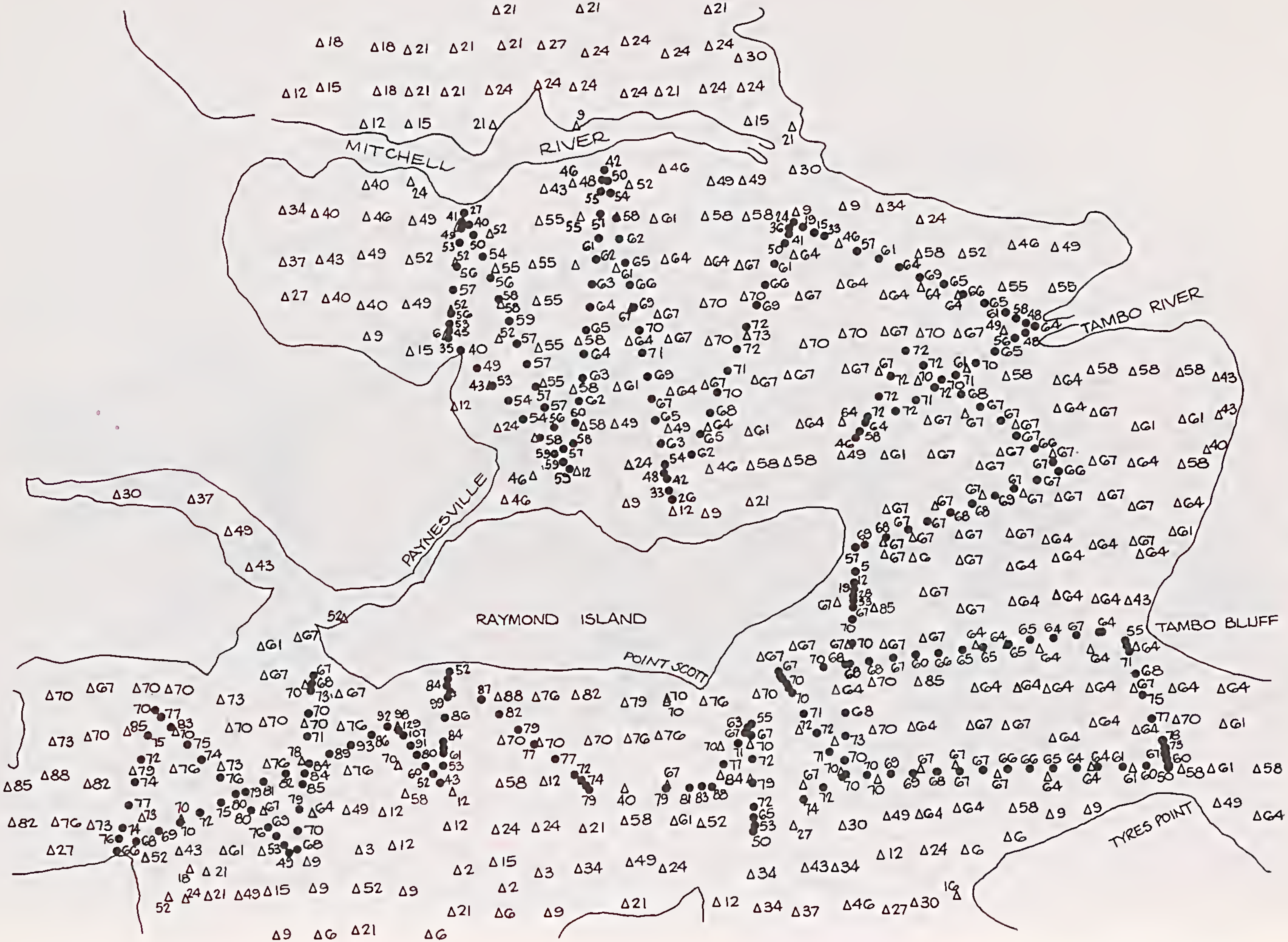

Fig. 3—Lake King—surveys of 1980 and 1893. Depths in decimetres. SEC △; Monash ●.

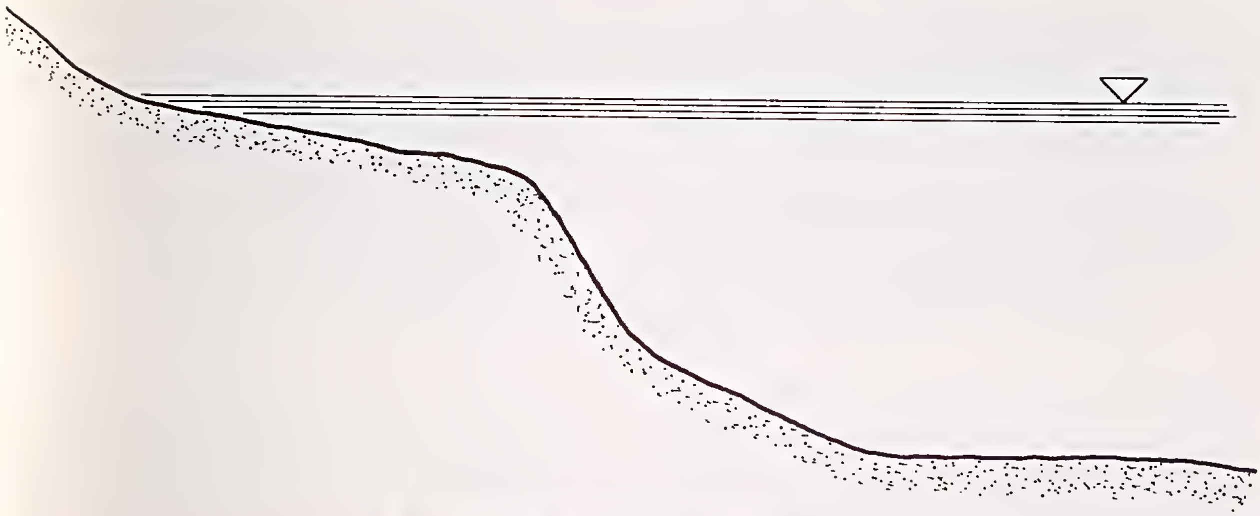

Fig. 4—Profile of the bed of Lake Victoria.

deeper. Thus, the channel at the entrance to the Tambo seems to be 0.5 m deeper; there is a new depression north of Raymond Island and off Point Scott. If it is supposed, then, that the broad areas of agreement indicate a situation stable since 1895, these deeper areas must represent bottom sediment carried away. This effect presumably results from the continuous flushing regime operating since the entrance has been kept open, coupled with the sharper flood peaks in the tributary rivers caused by more intensive settlement and land clearing. These measurements, unhappily, are not dense enough to estimate reliably how much material may have been lost in this way. Mason's survey was made just after the present entrance was dredged and stabilised, so we have no data on conditions prior to that. However, collateral evidence from the echo-sounder does give an indication of some aspects of the long term history of the lake system, which we take up below.

MORPHOLOGY

The profiles obtained in traversing display a characteristic cross-section for Lake Victoria shown in Fig. 4. From the shoreline there is gradual slope of about 1 in 150 out to a depth of about 1 m. The depth then drops very sharply to about 2.5 m before continuing on a slope of about 1 in 7 down to 3 m. The bed then becomes flat or slopes very gently down to its maximum depth of 3-6 m depending upon the position of the traverse within Lake Victoria. This break in slope appears very consistently and would seem to indicate a wave-cut step; however, the evidence of the echo-sounder suggests otherwise. The echo-sounder was operated on full gain, utilising a high-powered narrow-beam transducer, with the result that weak echoes were received from layers of sediment below the bed of the Lake. These echoes showed that the strata which form the uppermost, gradually sloping, section are continuous with those forming the steeper section. The lower gradually sloping or horizontal bed consists of layers of sediment laid above these steeply dipping strata.

The frequency of the echo-sounder was not chosen for sub-bottom profiling, and only small penetration of the bed was possible. Furthermore, the penetration of the bed achieved far from the shore did not result in coherent echoes. The latter result was also obtained by King (1980) utilising a much lower, and hence more suitable, frequency. King decided that gas bubbles within the deposited sediments were producing an incoherent back-scatter and preventing information on the underlying strata being obtained by acoustic techniques. King also showed, for the two or three sounding traverses which extended from the nearshore to the deeper waters, that the strata forming the steeply sloping sections of the channel bed appeared to dive below the strata forming the generally horizontal, central part of the bed.

The inference to be drawn from the echo sounding is that gradual deposition of silt occurred on the steeply sloping faces of natural levees and on the margins of the lakes. Since then, the lakes have been the site of gradual depostion of fine sediment and organic material deposited in relatively horizontal strata resting unconformably on the steeper strata. A more tranquil situation with a lower total sediment load seems likely in this later regime.

The small scale features on the echo-sounder traces were examined, but no evidence of sand dunes or sand waves was found in Lake Victoria. There were differences in the strength of the returned echo and in the noise accompanying the return, indicated by the length and regularity of the dashed line the upper surface of which describes the sea bed. Attempts were made to correlate the nature of the returned echo with the texture of the sea bed, as determined by sampling the sediment and by observing the presence or absence of weed. A rather subjective correlation was obtained and confirmed that the shallow gradual slope of the lake (near the shore) was weed covered on most traverse lines while the deeper gradual slope was not covered by weed, and in fact was bare silt in most cases. This technique of determining the nature of the bottom from interpretation of the echo-sounder traces warrants further study.

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